A
LETTER
TO

The Right Honourable

GEORGE

EARL OF MACCLESFIELD.

CONCERNING

An Apparent Motion obſerved in ſome of the

FIXED STARS.

By Jᴀᴍᴇꜱ Bʀᴀᴅʟᴇʏ, *D. D.*

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LONDON:

Printed in the Year

M. DCC. XLVII.

A
LETTER

To the RIGHT HONOURABLE

GEORGE *Earl of* MACCLESFIELD.

My LORD,

THE great Exactness, with which Instruments are now constructed, hath enabled the Astronomers of the present Age to discover several Changes in the Positions of the heavenly Bodies; which, by reason of their *Smallness*, had escaped the Notice of their Predecessors. And altho' the Causes of such Motions have always subsisted, yet Philosophers had not so fully consider'd what the Effects of those known Causes would be, as to demonstrate *a priori* the *Phænomena* they might produce; so that Theory itself is here, as well as in many other Cases, indebted to Practice, for the Discovery of some of its most elegant Deductions. This points out to us the great Advantage of cultivating *this*, as well as every other Branch of Natural Knowledge, by a regular Series of Observations and Experiments.

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The Progress of Astronomy indeed has always been found, to have so great a Dependence upon accurate Observations, that, till such were made, it advanced but slowly: For the first considerable Improvements that it received, in point of Theory, were owing to the renowned *Tycho Brahè*; who far exceeding those that had gone before him, in the Exactness of his Observations, enabled the sagacious *Kepler* to find out some of the principal Laws, relating to the Motion of the heavenly Bodies. The Invention of Telescopes and Pendulum-Clocks affording proper Means of still farther improving the *Praxis* of Astronomy; and these being also soon succeeded by the wonderful Discoveries made by our Great *Newton,* as to its Theory; the Science, in both respects, had acquired such extraordinary Advancement, that future Ages seemed to have little room left, for making any great Improvements. But, in fact, we find the Case to be very different; for, as we advance in the means of making more nice Inquiries, new Points generally offer themselves, that demand our Attention. The Subject of my present Letter to your Lordship, is a Proof of the Truth of this Remark: for, as soon as I had discovered the Cause, and settled the Laws of the Aberrations of the fixed Stars, arising from the Motion of Light, *&c.* whereof I gave an Account in N°. 406. of the *Philosophical Transactions*; my Attention was again excited by another *new Phænomenon, viz.* an annual Change of Declination in some of the fixed Stars; which appeared to be sensibly *greater* about that time, than a Precession of the Equinoctial Points of 50″ in a Year would have occasioned.

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The Quantity of the Difference, tho' small in itself, was rendered perceptible, thro' the Exactness of my Instrument, even in the first Year of my Observations; but being then at a Loss to guess, from what Cause that greater Change of Declination proceeded, I endeavoured to allow for it in my Computations, by making use of the *observed* annual Difference, as mentioned in *p.* 652. of the same *Transaction*.

From *that* time to the present, I have continued to make Observations at *Wansted*, as Opportunity offered, with a View of discovering the Laws and Cause of this *Phænomenon:* For, by the Favour of my very kind and worthy Friend *Matthew Wymondesold* Esq, my Instrument has remained where it was first erected; so that I have been able, without any Interruption, which the Removal of it to another Place would have occasioned, to proceed on with my intended Series of Observations, for the Space of twenty Years: a Term somewhat exceeding the whole Period of the Changes, that happen in this *Phænomenon.*

When I shall mention the *small* Quantity of the Deviation, which the Stars are subject to, from the Cause that I have been so long searching after; I am apprehensive, that I may incur the Censure of some Persons, for having spent so much Time in the Pursuit of such a seeming Trifle: But the candid Lovers of Science will, I hope, make due Allowance for that natural Ardour, with which the Mind is urged on towards the Discovery of Truths, in themselves perhaps of *small* Moment, were it not that they tend to illustrate others of greater Use.

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The apparent Motions of the heavenly Bodies are so complicated, and affected by such a Variety of Causes; that in many Cases it is extremely difficult to assign to each its due Share of Influence; or distinctly to point out, what Part of the Motion is the Effect of one Cause, and what of another: And whilst the joint Effects of *All* are only attended to, great Irregularities and seeming Inconsistencies frequently occur; whereas, when we are able to allot to each particular Cause its proper Effect, Harmony and Uniformity usually ensue.

Such seeming Irregularities being also blended with the unavoidable Errors, which Astronomical Observations must be always liable to, as well from the Imperfection of our Senses, as of the Instruments that we make use of) have often very much perplex'd those, who have attempted to solve the *Phænomena* : and till Means are discovered, whereby we can separate and distinguish the *particular* Part of the whole Motion, that is owing to each respective Cause, it will be impossible, to be well assured of the Truth of any Solution. For these Reasons, we generally find, that the more exact the Instruments are, that we make use of, and the more regular the Series of Observations is, that we take; the sooner we are enabled to discover the Cause of any new *Phænomenon*. For when we can be well assured of the Limits, wherein the Errors of the Observations are contain'd; and have reduced them within as narrow Bounds as possible, by the Perfection of the Instruments which we employ; we need not hesitate to ascribe such apparent Changes, as manifestly exceed those Limits, to some other Causes. Upon
these

thefe Accounts it is incumbent upon the *practical* Aftronomer, to fet out at firft with the Examination of the Correctnefs of his Inftruments; and to be affured that they are fufficiently exact for the Ufe he intends to make of them : or at leaft he fhould know, within what Limits their Errors are confined.

This Practice has, in an eminent manner, been lately recommended by your Lordfhip's noble Example; who having, out of a fingular Regard for the Science of Aftronomy, erected an Obfervatory, and furnifhed it with as complete an *Apparatus* of Inftruments, as our beft Artifts could contrive; would not fully rely on their Exactnefs, till their Divifions had undergone the ftricteft Re-examination : whereby they are probably now render'd as perfect in their kind, as any extant, or as human Skill can at prefent produce.

The Lovers of *this* Science in general, cannot but acknowledge their Obligations to your Lordfhip on this Account; but I find myfelf more particularly bound to do it; fince, by means of your Lordfhip's moft accurate Obfervations, I have been enabled to fettle fome *principal Elements*; which I could not at prefent otherwife have done, for want of an Inftrument at the Royal Obfervatory, *proper* for that Purpofe : For the large *mural Quadrant*, which is there fixed to obferve Objects lying Southward of the Zenith, however *perfect* an Inftrument it may be in it felf, is not *alone* fufficient to determine, with proper Exactnefs, either the *Latitude* of the Obfervatory, or the Quantity of Refraction correfponding to different Altitudes : For it being too heavy to be conveniently removed; and the Room wherein it is placed, being too fmall to admit of its

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being turned to the opposite Side of the Wall, whereon it now hangs; I cannot, by *actual* Observations of the circumpolar Stars, settle those necessary Points; and therefore have endeavoured to do it, by comparing my own with your Lordship's Observations: and until this Defect in the *Apparatus* belonging to the Royal Observatory be removed, we must be indebted to your Lordship, for the Knowledge of its true Situation.

A Mind intent upon the Pursuit of any kind of Knowledge, will always be agreeably entertained, with what can supply the most proper means of attaining it: Such, to the practical Astronomer, are exact and well-contriv'd Instruments; And I reflect with Pleasure on the Opportunities I have enjoyed, of cultivating an Acquaintance and Friendship with the Person, that, of all others, has most contributed to their Improvement. For I am sensible, that if my own Endeavours have, in any respect, been effectual to the Advancement of Astronomy; it has principally been owing to the Advice and Assistance given me by our worthy Member Mr. *George Graham*; whose great Skill and Judgment in Mechanicks, join'd with a complete and practical Knowledge of the Uses of Astronomical Instruments, enable him to contrive and execute them in the most perfect manner.

The Gentlemen of the *Royal Academy* of *Sciences*, to whom we are so highly obliged for their exact Admeasurement of the Quantity of a Degree under the Arctic Circle, have already given the World very convincing Proofs of *his* Care and Abilities in those Respects; and the particular Delineation, which they have lately published, of the several Parts

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of the *Sector*, which he made for them, hath now rendered it needlefs, to enter upon any minute Defcription of *mine* at *Wanfted*; both being conftructed upon the fame Principles, and differing in their component Parts, chiefly on account of the different Purpofes, for which they were intended.

As mine was originally defigned to take only the *Differences* of the Zenith Diftances of Stars, in the various Seafons of the Year, without any View of difcovering their *true* Places; I had no Occafion to know exactly, what Point on the Limb correfponded to the *true* Zenith : and therefore no Provifion was made in my Sector, for the changing of its Situation for that Purpofe. Neither was it neceffary that the Divifions or Points on the Arc fhould be fet off, with the utmoft Accuracy, Equidiftant from each other ; becaufe, when I obferve any particular Star, the fame Spot or Point being firft bifected by the Plumb-line, and then the Screw of the Micrometer turn'd until the Star appears upon the middle of the Wire, that is fixed in the common Focus of the Glaffes of the Telefcope; I can thereby collect, how far the Star is from that given Point at the Time of Obfervation : and afterwards, by comparing together the feveral Obfervations that are made of it, I am able to difcover what apparent Change has happen'd. The Quantity of the vifible Alteration, in the Pofition of the Stars, being expreffed by Revolutions and Parts of a Revolution, of the Screw of the Micrometer; I endeavoured to determine, with great Care, the true Angle anfwering thereto: and after various Trials, I thoroughly fatisfied myfelf, both of the Equality of

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the Threads of the Screw, and of the precise Number of Seconds corresponding to them.

But altho' these Points could be settled with great Certainty, I was nevertheless obliged to make one Supposition; which perhaps to some Persons may seem of too great Moment in the present Inquiry, to be admitted without an evident Proof from Facts and Experiments. For I *suppose*, that the Line of Collimation of my Telescope has invariably preserved the same Direction, with respect to the Divisions upon the Arc, during the whole Course of my Observations. And indeed it was on account of the Objections, which might have been raised against such a *Postulate*, that I thought it necessary, to continue my Series of Observations for so many Years, before I published the Conclusions, which I shall at present endeavour to draw from them.

Whoever compares the Result of the several Trials, that have been made by the Gentlemen of the *Academy* of *Sciences*, for determining the Zenith Point of their Sector, since their Return from the North; will, I presume, allow that *mine* is not an unreasonable or precarious *Supposition*: since it is evident, from their Observations, that the Line of Collimation of that Instrument underwent no sensible Change in its Direction, during the Space of more than a whole Year; altho' it was several times taken down, and set up again in different and remote Places; whereas *mine* hath always remained suspended in the same Place.

But besides such a strong Argument for the Probability of the Truth of my *Supposition*, I have the Satisfaction of finding it *actually* verified by the

Observations

Obſervations themſelves; which plainly prove, that at the End of the full Period of the Deviations which I am going to mention, the Stars are found to have the ſame Poſitions by the Inſtrument, as they ought to *have*, ſuppoſing the Line of Collimation to have continued unaltered from the Time when I firſt began to obſerve.

I have already taken notice, in what manner this *Phænomenon* diſcover'd itſelf to me at the End of my firſt Year's Obſervations, *viz.* by a *greater* apparent Change of Declination in the Stars near the Equinoctial Colure, than could ariſe from a Preceſſion of 50″ in a Year; the mean Quantity now uſually allowed by Aſtronomers. But there appearing at the ſame time, an Effect of a quite contrary Nature, in ſome Stars near the Solſtitial Colure, which ſeem'd to alter their Declination *leſs* than a Preceſſion of 50″ required; I was thereby convincéd, that all the *Phænomena*, in the different Stars, could not be accounted for, merely by ſuppoſing, that I had aſſumed a wrong Quantity for the Preceſſion of the Equinoctial Points.

At firſt, I had a Suſpicion, that ſome of theſe ſmall apparent Alterations in the Places of the Stars, might poſſibly be occaſioned by a Change, in the Materials, or in the Poſition of the Parts of my Sector: But, upon conſidering how firmly the Arc, on which the Diviſions or Points are made, is faſtened to the Plate, wherein the Wire is fixed that lies in the Focus of the Object-Glaſs; I ſaw no Reaſon to apprehend, that any Change could have happened in the Poſition of that Wire and thoſe Points. The Suſpenſion therefore of the Plummet being the moſt likely Cauſe, from whence I conceived any Uncer-

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tainty could arife; and the Wire of which had been broken three or four times in the firft Year of my Obfervations: I attempted to examine, whether Part of the 'foremention'd apparent Motions might not have been owing, to the different Plumb-lines that had been made ufe of. In order to determine this, I adjufted a particular Point of the Arc to the Plumb-line, with all the Exactnefs I could; and then taking off the old Wire, I immediately hung on another, with which the fame Spot was again compared. I repeated the Experiment three or four times, and thereby fully fatisfied myfelf, that no fenfible Error could arife from the Ufe of different Plumb-lines; fince the various Adjuftments of the fame Point agreed with each other, within lefs than half a Second.

Having then, from fuch Trials, fufficient Reafon to conclude, that thefe *fecond* unexpected Deviations of the Stars, were not owing to any Imperfection of my Inftrument; after I had fettled the Laws of the Aberrations arifing from the Motion of Light, *&c.* I judged it proper to continue my Obfervations of the fame Stars; hoping that, by a regular and longer Series of them, carried on thro' feveral fucceeding Years, I might, at length, be enabled to difcover the *real* Caufe of fuch apparent Inconfiftencies.

As I refided chiefly at *Wanfted*, after my Sector was erected there in the Year 1727. till the Beginning of *May* 1732. when I removed from thence to *Oxford*: I had, during my Abode at *Wanfted*, frequent Opportunities of repeating my Obfervations; and thereby difcovered fo many Particulars relating

to
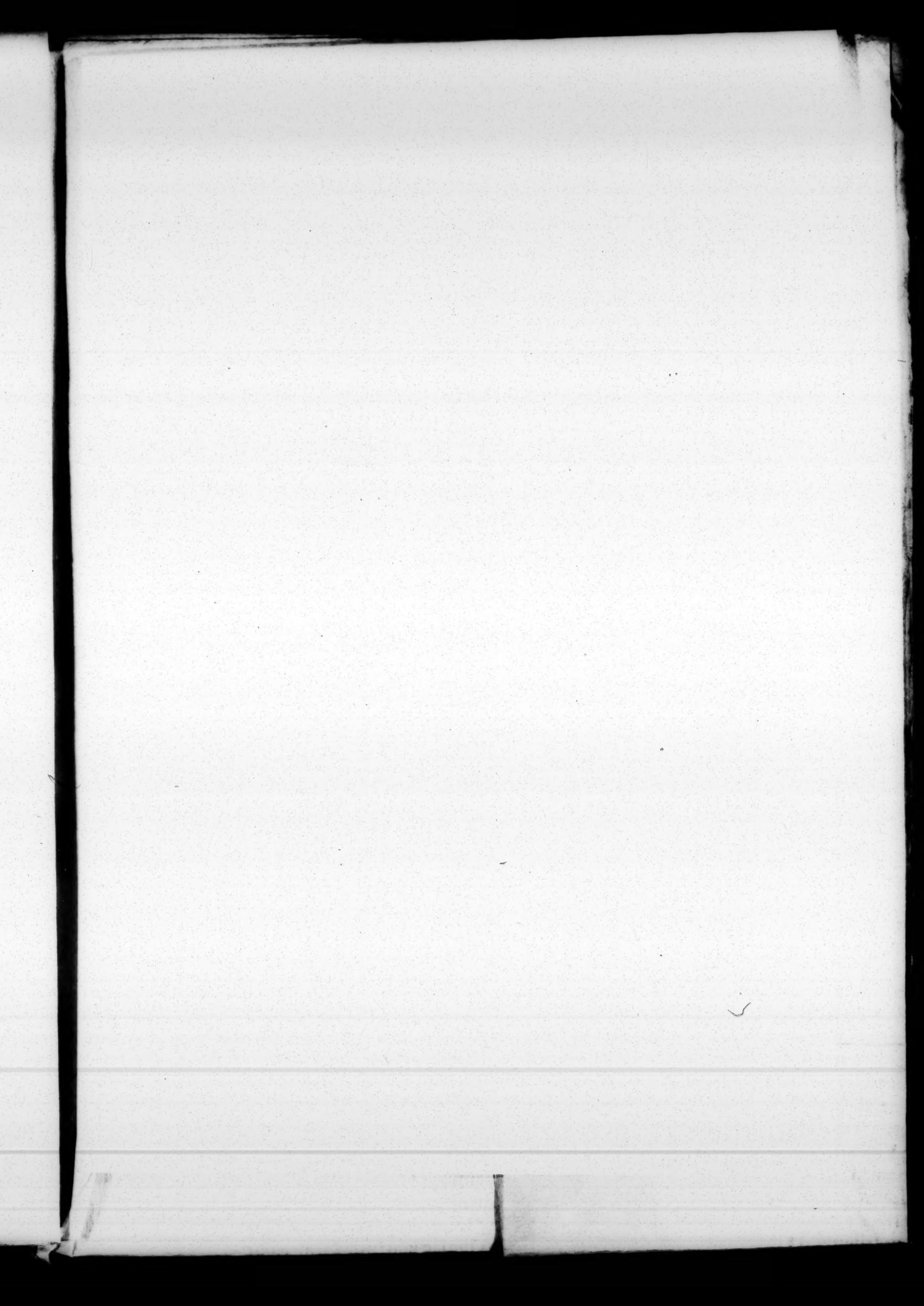
HONORI

Illuſtris viri , nobiliſſimi Jurisconſulti , Conſultiſſimi
Reip. Amſtelodamenſis Senatoris ,

NICOLAI WITSENII,

Navium regimen & ornatum commentati,

Libens Meritoque poſuit

SAMUEL TENNULIUS.

Magnificus Noviomagenſis univerſitatis Rector & Profeſſor.

Prima per inſtabiles vexit Symplega-
　　das Argo ;
Cui freta flammiferos dederunt coë-
　　untia campos,
Bosporus & Scythicæ Phœbæi Phaſi-
　　dos undæ.
Qualia pertentant repetita prole leones
Gaudia, ſervatum venerantur Iaſona matres :
Auditus Pelian frendentem terruit altæ
Lætitiæ clamor tacitusque triumphus ; ut albus
Cum fugit Eōis tigres Hyrcanus in arvis
Raptor, & ereptis metuit ſua vulnera prædis.
Hanc Reges preſſere ratem. Vos heu quibus ipſam,
Numina, jactaſtis fatis quantisque periclis!
Acta metu vario, puppim intercepta loquacem,
Curſum ad profeſſæ, tenuit confinia mortis.
Tunc Virgo Medea ſuis crudelior undis ;
Ivit in omne nefas conjux viduata marito.
Non tot in occiduo fuerant diſcrimina ponto,
Cum bene *Pacificum*, ventis bellantibus, æquor
Deprendens, varios per clauſtra gementia montes,
Dura *Magellanes* laxavit vincula mundi. (triones,
Nempe tuos nondum ad ſeptem , *Nova Zembla* ,
Aut Libyam extremam dimiſerat *Amſtela* naves.
Non orientis opes, ſeptena per oſtia Gangæ
India quas mittit, non Serum vellera pinus
Ulla ſequebatur, *Limamve , Peruve* ; nec auri
Tunc *Quitoniaci* licuit tentare metalla.
Cur , Natura parens, obliqua ad ſidera Cancri
Partibus ex æquis partitus quattuor orbem,
Sole coronatum, circumfluit undique pontus,
Si non admôrunt propius compendia ſeras ?
An timuit Divum convivia nauta bonorum,
Aſtrorumque ſuis violare cubilia velis ?
An , cui ſe debent homines, Hyperione natus,
Cum preſſere polum , ſtridenti terruit unda ?
Fabula , rumores nobis & inania verba :
Scilicet hæc Minyis , Di magni, credita priſcis !
Finxerat haud Hyadas Grajus, nec Plauſtra Bootæ ;
Nomina non venti nec habebant membra carinæ :
Witſenius radio nondum deſcripſerat heros
Velorum celeresque pedes legesque fororum,
Compages laterum & cuneis fundantibus arctas ;
Tutelas proris, antennis cornua , tonſas
Nec dederat tranſtris, nec pondera juſta carinis.
Flamina diverſo tractu laniantia terras

Ingeniumque loci (patriæ cuſtodia noſtræ)
Puppibus, arcuerant, Belgas ne intraret Iberus.
Ecce aliam faciem rerum ! Tranquilla poteſtas
Jura magiſtratusque legit. Reſpublica navis
Quæque eſt ; obſequitur non ulla furentibus Euris :
Verum ubi conſtituit , lignis confiſus , habenas
Omnibus immittit ventis auriga , per altum
Naturæ faciens litem nunc æmulus errat,
Atque coronata repetit cum puppe parentes.
Viſceribus quicquid Tellus generoſa recondit,
Quodque alit in ſummo, video ſuperare Batavis :
Jam video cives Obium Gangenque bibentes,
Exercere agros , oriens quos truſit in æquor.
Per mare jam video, magnum per inane volantem
Remigio alarum velorum Dædalon alis.
Parta in cæruleis libertas aurea campis,
Concedat natura viam, meditatur in aſtra.
Jam periere modi terrarum & fœdera rerum :
Cuncta patent, nullum præcludunt ſidera pontum ;
Nil mare juris habet : Boreæ ſine viribus ira ,
Et ſua regna peti queritur Neptunus in undis :
Witſenius metuendus enim, non Vincula Xerxis.
Witſenius ſæclis venturis utile nomen ,
Per quem nullus equos flexit, decurrere campo,
Et peragrare loca intentata prioribus auſus,
Opportuna ſuis metatur quæque triumphis ;
Inde Syracuſii faciet ſenis artibus umbram.
Haſce manus Babylon , has ipſa Semiramis optet ,
Has Trivia & Rhodus, has Cares mirentur & Ammon,
Elis & has toto quæſiſſet Memphis in orbe.
Perplexas quoties ageret facundia cauſas ,
Ipſius voluiſſe loqui ſermone Minervam
Cecropiam fama eſt , ſi cum mortalibus eſſet
Ore loqui Divis : Tantis virtutibus æqua
Præmia quando feret ? dignas perſolvere grates
Curarum ô utinam poſſent monumenta mearum !
Vidit ut Auguſtum nemo ſine munere vultum
Regis Achæmenii ; vacuus quis adibit amoris
Tanti templa viri ? ſed tanta potentia mentis
Hunc animum Lymphęque volam pro munere ſumet.
Sic tua nimboſas, Rector, quandoque procellas
Puppis, & infidum ſubſtringens vela ſerenum
Vitet, & iratum, quod tollet Cynthia , ſidus :
Sic tua Livorem ſuperet feliciter ætas ,
Ut patrio virtus non circumſcribitur orbe.
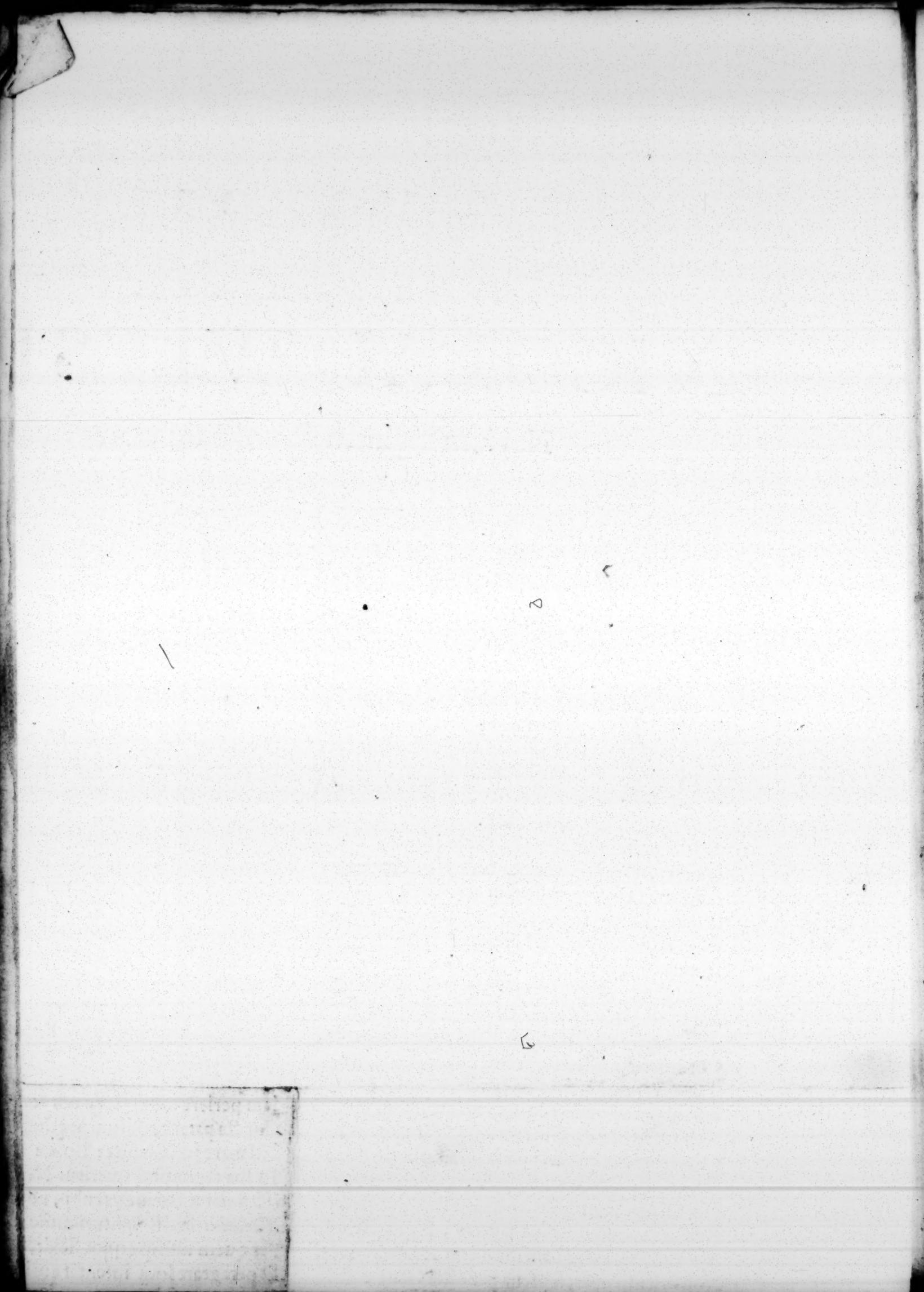
to thefe *Phænomena*, that I began to guefs what was the real Caufe of them.

It appeared from my Obfervations, that, during this Interval of Time, fome of the Stars near the Solftitial Colure, had changed their Declinations 9″ or 10″ *lefs*, than a Preceffion of 50″ would have produced ; and, at the fame time, that, others near the Equinoctial Colure, had altered theirs about the fame Quantity *more*, than a like Preceffion would have occafioned : the North Pole of the Equator feeming to have approached the Stars, which come to the Meridian with the Sun, about the Vernal Equinox and the Winter Solftice ; and to have receded from thofe, which come to the Meridian with the Sun, about the Autumnal Equinox and the Summer Solftice.

When I confider'd thefe Circumftances, and the Situation of the Afcending Node of the Moon's Orbit, at the time when I firft began my Obfervations ; I fufpected, that the Moon's Action upon the Equatorial Parts of the Earth might produce thefe Effects : For, if the Preceffion of the Equinox be, according to Sir *Ifaac Newton*'s Principles, caufed by the Actions of the Sun and Moon upon thofe Parts ; the Plane of the Moon's Orbit being at *one* time, above ten Degrees *more* inclined to the Plane of the Equator, than at *another* ; it was reafonable to conclude, that the Part of the whole annual Preceffion, which arifes from her Action, would in different Years be varied in its Quantity ; whereas the Plane of the Ecliptic, wherein the Sun appears, keeping always nearly the fame Inclination to the Equator ; *that* Part of the Preceffion, which is owing to the Sun's Action, may be the fame every

Year :

Year: And from hence it would follow, that, altho'
the *mean* annual Preceſſion, proceeding from the
joint Actions of the Sun and Moon, were 50"; yet
the *apparent* annual Preceſſion might ſometimes ex-
ceed, and ſometimes fall ſhort, of that mean Quan-
tity, according to the various Situations of the Nodes
of the Moon's Orbit.

In the Year 1727. when my Inſtrument was firſt
ſet up, the Moon's Aſcending Node was near the
Beginning of *Aries*; and conſequently, her Orbit
was as much inclined to the Equator, as it can at
any time be; and then the *apparent* annual Preceſſion
was found, by my firſt Year's Obſervations, to be
greater than the *mean:* which proved, that the
Stars near the Equinoctial Colure, whoſe Declina-
tions are moſt of all affected by the Preceſſion, had
changed *theirs*, above a tenth Part more than a Pre-
ceſſion of 50" would have cauſed. The ſucceeding
Years Obſervations proved the ſame Thing; and
in three or four Years time the Difference be-
came ſo conſiderable, as to leave no Room to ſuſ-
pect, that it was owing to any Imperfection, either
of the Inſtrument or Obſervations.

But ſome of the Stars, which I had obſerved, that
were near the Solſtitial Colure, having appeared to
move, during the ſame time, in a manner contrary
to what they ought to have done, by an Increaſe in
the Preceſſion; and the Deviations in them being
as remarkable as in the others, I perceived that ſome-
thing more, than a mere Change in the Quantity of
the Preceſſion, would be requiſite to ſolve this Part
of the *Phænomenon*. Upon comparing my Obſer-
vations of Stars near the Solſtitial Colure, that were

almoſt

almoſt oppoſite to each other in Right Aſcenſion, I found, that they were equally affected by this Cauſe; for whilſt γ *Draconis* appeared to have moved Northward, the ſmall Star, which is the 35th *Camelopardali Hevel.* in the *Britiſh* Catalogue, ſeem'd to have gone as much towards the South : which ſhew'd, that this apparent Motion, in both thoſe Stars, might proceed from a Nutation in the Earth's Axis; whereas the Compariſon of my Obſervations of the ſame Stars, *formerly* enabled me to draw a different Concluſion, with reſpect to the Cauſe of the annual Aberrations ariſing from the Motion of Light. For the apparent Alteration in γ *Draconis*, from *that* Cauſe, being as great again as in the other ſmall Star, proved, that *that Phænomenon* did not proceed from a *Nutation* of the Earth's Axis; as, on the contrary, *this* may. Upon making the like Compariſon between the Obſervations of other Stars, that lie nearly oppoſite in Right Aſcenſion, whatever their Situations were with reſpect to the Cardinal Points of the Equator, it appeared, that their Change of Declination was nearly equal, but contrary; and ſuch as a Nutation or Motion of the Earth's Axis would effect.

The Moon's Aſcending Node being got back towards the Beginning of *Capricorn* in the Year 1732. the Stars near the Equinoctial Colure appeared, about that time, to change their Declinations no more, than a Preceſſion of 50″ required; whilſt ſome of thoſe near the Solſtitial Colure altered *theirs* above 2″ in a Year leſs, than they ought. Soon after, I perceived the annual Change of Declination of the former to be diminiſhed, ſo as to become *leſs* than

50″

50" of Precession would cause; and it continued to diminish till the Year 1736. when the Moon's Ascending Node was about the Beginning of *Libra*, and her Orbit had the *least* Inclination to the Equator. But by this time, some of the Stars near the Solstitial Colure had altered their Declinations 18" *less*, since the Year 1727. than they ought to have done from a Precession of 50". For γ *Draconis*, which in those nine Years should have gone about 8" more *Southerly*, was observed in 1736. to appear 10" more *Northerly*, than it did in the Year 1727.

As this Appearance in γ *Draconis*, indicated a Diminution of the Inclination of the Earth's Axis to the Plane of the Ecliptic; and as several Astronomers have supposed *that* Inclination to diminish regularly; if this *Phænomenon* depended upon such a Cause, and amounted to 18" in nine Years, the Obliquity of the Ecliptic would, at that rate, alter a whole Minute in thirty Years; which is much faster than any Observations, *before* made, would allow. I had Reason therefore to think, that *some Part* of this Motion at the least, if not the *Whole*, was owing to the Moon's Action upon the Equatorial Parts of the Earth; which I conceived, might cause a libratory Motion of the Earth's Axis. But as I was unable to judge, from only nine Years Observations, whether the Axis would entirely recover the same Position, that it had in the Year 1727. I found it necessary to continue my Observations thro' a whole Period of the Moon's Nodes; at the End of which I had the Satisfaction to see, that the Stars returned into the same Positions again; as if there had been no Alteration at all in the Inclination of the Earth's Axis: which

which fully convinced me, that I had gueſſed rightly as to the Cauſe of the *Phænomena*. This Circumſtance proves likewiſe, that if there be a gradual Diminution of the Obliquity of the Ecliptic; it does not ariſe only from an Alteration in the Poſition of the Earth's Axis, but rather from ſome Change in the Plane of the Ecliptic itſelf: becauſe the Stars, at the End of the Period of the Moon's Nodes, appeared in the ſame Places, with reſpect to the Equator, as they ought to have done, if the Earth's Axis had retained the ſame Inclination to an invariable Plane.

During the Courſe of my Obſervations, our ingenious Secretary of the *Royal Society*, Mr. *John Machin*, being employed in conſidering the Theory of Gravity; and its Conſequences, with regard to the Celeſtial Motions; I acquainted him with the *Phænomena* that I had obſerved: and at the ſame time mentioned, *what* I ſuſpected to be the Cauſe of them. He ſoon after ſent me a Table, containing the Quantity of the annual Preceſſion in the various Poſitions of the Moon's Nodes, as alſo the correſponding Nutations of the Earth's Axis; which was computed upon the *Suppoſition*, that the *mean* annual Preceſſion is 50", and that the Whole is governed by the Pole of the Moon's Orbit only: and therefore he imagined, that the Numbers in the Table would be too *large*; as in Fact they were found to be. But it appeared, that the Changes which I had obſerved, both in the annual Preceſ-ſion and Nutation, kept the ſame Law, as to in-creaſing and decreaſing, with the Numbers of his Table. Thoſe were calculated upon the Suppoſition,

C

that

that the Pole of the Equator, during a Period of the Moon's Nodes, moved round in the Periphery of a little Circle, whose Center was 23° 29' distant from the Pole of the Ecliptic; having itself also an angular Motion of 50″ in a Year, about the same Pole: The North Pole of the Equator was conceived to be in *that* Part of the small Circle, which is farthest from the North Pole of the Ecliptic, at the Time when the Moon's Ascending Node is in the Beginning of *Aries*: and in the opposite Point of it, when the same Node is in *Libra*.

Such a Hypothesis will account for an Acceleration and Retardation of the annual Precession; as also for a Nutation of the Earth's Axis: And if the Diameter of the little Circle be supposed equal to 18″; which is the whole Quantity of the Nutation, as collected from my Observations of *γ Draconis*: then all the *Phænomena* in the several Stars which I observed, will be very nearly solved by it.

Let *P* represent the mean Place of the Pole of the Equator, about which Point, as a Center, suppose the true Pole to move in the Circle *ABCD*, whose Diameter is 18″. Let *E* be the Pole of the Ecliptic; and *E P* be equal to the mean Distance between the Poles of the the Equator and Ecliptic; and suppose the true Pole
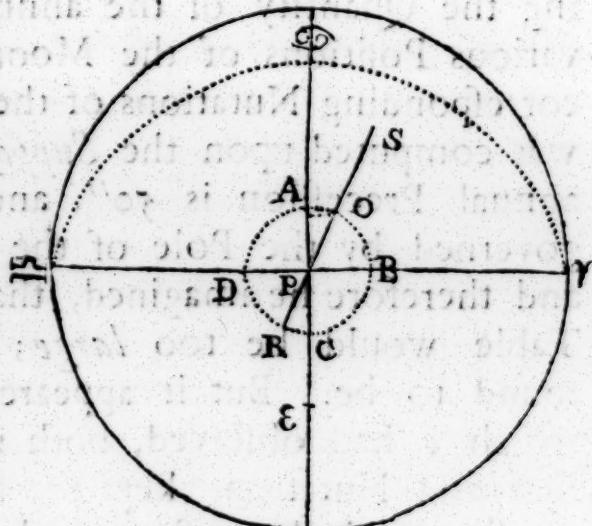
Pole of the Equator to be at *A*, when the Moon's Ascending Node is in the Beginning of *Aries*; and at *B*, when the Node gets back to *Capricorn*; and at *C*, when the same Node is in *Libra*: at which time the North Pole of the Equator being nearer the North Pole of the Ecliptic, by the whole Diameter of the little Circle *AC* equal to 18″; the Obliquity of the Ecliptic will then be so much *less* than it was, when the Moon's Ascending Node was in *Aries*. The Point *P* is supposed to move round *E*, with an equal retrograde Motion, answerable to the mean Precession arising from the joint Actions of the Sun and Moon: while the true Pole of the Equator moves round *P*, in the Circumference *ABCD*, with a retrograde Motion likewise, in a Period of the Moon's Nodes, or of eighteen Years, and seven Months. By this means, when the Moon's Ascending Node is in *Aries*, and the true Pole of the Equator at *A*, is moving from *A* towards *B*: it will approach the Stars, that come to the Meridian with the Sun about the Vernal Equinox; and recede from those that come with the Sun near the Autumnal Equinox, *faster* than the *mean* Pole *P* does. So that, while the Moon's Node goes back from *Aries* to *Capricorn*, the *apparent* Precession will seem so much *greater* than the *mean*; as to cause the Stars, that lie in the Equinoctial Colure; to have altered their Declination 9″, in about four Years and eight Months, *more* than the mean Precession would do: and in the same time, the North Pole of the Equator will seem to have approached the Stars, that come to the Meridian with the Sun at our Winter Solstice, about 9″; and to have receded as *much* from those, that come with the Sun at the Summer-Solstice.

Thus

Thus the *Phænomena* before recited are in general conformable to this Hypothesis. But to be more particular; let *S* be the Place of a Star, *PS* the Circle of Declination passing thro' it, representing its Distance from the mean Pole, and *ɣPS* its mean Right Ascension. Then if *O* and *R* be the Points, where the Circle of Declination cuts the little Circle *ABCD*; the *true* Pole will be nearest that Star at *O*, and farthest from it at *R*; the whole Difference amounting to 18", or to the Diameter of the little Circle. As the true Pole of the Equator is supposed to be at *A*, when the Moon's Ascending Node is in *Aries*; and at *B*, when that Node gets back to *Capricorn*; and the angular Motion of the true Pole about *P*, is likewise supposed equal to that of the Moon's Node about *E*, or the Pole of the Ecliptic: since, in these Cases, the true Pole of the Equator is 90 Degrees before the Moon's Ascending Node, it must be so in all others.

When the true Pole is at *A*, it will be at the same Distance from the Stars that lie in the Equinoctial Colure, as the mean Pole *P* is; for I neglect at present the Case of such Stars as are *very* near the Pole of the Equator; and as the true Pole recedes back from *A* towards *B*, it will approach the Stars, that lie in that Part of the Colure represented by *Pɣ*; and recede from those, that lie in *P≏*; not
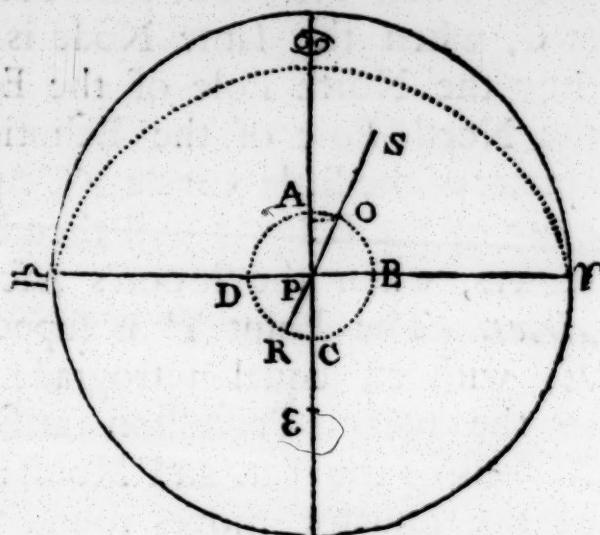
indeed

indeed with an *equable* Motion; but in the *Ratio* of the *Sine* of the Diſtance of the Moon's Node from the Beginning of *Aries*. For if the Node be ſuppoſed to have gone backwards from *Aries* 30°, or to the Beginning of *Piſces*; the Point, which repreſents the Place of the true Pole, will in the mean time, have moved in the little Circle, thro' an Arc, as *AO*, of 30° likewiſe: and would therefore in Effect have approached the Stars that lie in the Equinoctial Colure $P\gamma$, and have receded from thoſe that lie in $P\simeq$, $4''\frac{1}{2}$; which is the *Sine* of 30° to the *Radius AP*. For if a Perpendicular fall from O upon PA, it may be conceived as Part of a great Circle, paſſing thro' the true Pole, and any Star lying in the Equinoctial Colure. Now the ſame Proportion, that holds in theſe Stars, will obtain likewiſe in all others; and from hence we may collect a general Rule, for finding how much nearer or farther, any particular Star is, to or from, the *mean* Pole, in any given Poſition of the Moon's Node.

For, if *from the Right-Aſcenſion of the Star, we ſubſtract the Diſtance of the Moon's Aſcending Node from Aries; then the Radius will be to the Sine of the Remainder, as 9", is to the Number of Seconds, that the Star is nearer to, or farther from the True, than the Mean Pole.* When that Remainder is *leſs* than 180°, the Star is *nearer* to the True, than to the Mean Pole; and the contrary, when it is *greater* than 180°.

This Motion of the *true* Pole, about the *mean* at P, will alſo produce a Change in the Right Aſcenſions of the Stars, and in the Places of the Equinoctial Points; as well as in the Obliquity of the Ecliptic:

tic: and the Quantity of the Equations, in either of thefe Cafes, may be eafily computed for any given Pofition of the Moon's Nodes. But as it may be needlefs, to dwell longer on the Explication of the Hypothefis; I fhall now proceed to fhew its Correfpondency with the *Phænomena*, relating to the Alterations of the Polar Diftances of fome of the Stars which I have obferved: by laying before your Lordfhip the Obfervations themfelves, together with the Computations that are neceffary; in order to form a right Judgment about the Caufe of thefe Appearances.

I have endeavoured to find the exact Quantity of the *mean* Preceffion of the Equinoctial Points, by comparing my own Obfervations made at *Greenwich*, with thofe of *Tycho Brahè* and others, which I judged to be moft proper for that Purpofe. But as many of the Stars, which I compared, gave a different Quantity; I fhall affume the mean Refult; which gives a Preceffion of one Degree in feventyone Years and an half: this agreeing very well likewife with my Obfervations that were taken at *Wanfted*. The Numbers in the following Tables, which exprefs the Change of Declination in each Star, are computed upon the Suppofition, that the *mean* Obliquity of the Ecliptic was 23°. 28'. 30", and that it continued the *fame*, during the whole Courfe of my Obfervations. And as the Moon's Afcending Node was in the Beginning of *Aries* about the 27th Day of *March* 1727, I have reduced the Place of each Star to *that* Time; by allowing the proper Change of Declination from that Day, to the Day of each refpective Obfervation.

It being alfo neceffary to make an Allowance for the *Aberrations* of Light; I have again examined my

my Obfervations, that were moft proper to determine the Tranfverfe Axis of the Ellipfis, which each Star feems to defcribe; and have found it to be neareft to 40"; which Number I therefore make ufe of in the following Computations.

The Divifions or Points upon the Limb of my Sector are placed five Minutes of a Degree from each other; and are numbered fo, as to fhew the Polar Diftances nearly; the *true* Polar Diftance exceeding that, which is fhewn by the Inftrument, about 1'. 35". When I firft began to obferve, I generally made ufe of *that* Point on the Limb, which was neareft to the Star's Polar Diftance, without regarding whether it was more Northerly, or more Southerly than the Star: but as it fometimes happened, that the Original Point, with which I at firft compared the Star, became, in Procefs of Time, pretty remote from it; I afterwards brought the Plummet to another Point, that was nearer to it; and carefully examined, what Number of Revolutions of the Screw of the Micrometer *&c.* correfponded to the Diftance between the different Points, that I had made ufe of: by which means I was able to reduce all the Obfervations of the fame Star to the fame Point, without fuppofing the feveral Divifions to be accurately 5' afunder.

I have expreffed the Diftance of each Star from the Point of the Arc, with which it was compared, in *Seconds* of a Degree and *tenth Parts* of a Second, exactly as it was collected from the Obfervations; altho' I am fenfible, that the Obfervations themfelves are liable to an Error of more than a *whole* Second; becaufe I meet with fome, that have been made within two or three Days of each other, that differ 2", even when they are not marked as *defective* in any refpect.   It

It would be too tedious, to set down the whole Number of the Observations that I have made; and therefore I shall give only enough of them, to shew their Correspondency with the 'forementioned Hypothesis in the several Years, wherein any were made of the Stars here recited. When *several* Observations have been taken of the same Star, within a few Days of each other; I have either set down the mean Result, or *that* Observation which best agreed with it. I have likewise commonly chosen those, that were made near the same Season of the Year, in such Stars as gave me the Opportunity of making that Choice; particularly in γ *Draconis*, which was generally observed about the End of *August* or the Beginning of *September*; *That* being the usual Time, when I went to *Wansted* on purpose to observe both *that*, and also some of the Stars in the *great Bear*. But the Weather proving cloudy at that Season in the Year 1744, prevented my making a single Observation, either of γ *Draconis*, or any other Star, while I was there; which is the Cause of one Vacancy in a Series of 20 succeeding Years, wherein that particular Star had been observed. Such Stars, as were either not visible in the Day-time, towards the Beginning of *September*, or came at such Hours of the Night, as would have incommoded the Family of the House wherein the Instrument is fixed, were but seldom observed, after I went to reside at *Oxford:* which is the Reason, why the Series of Observations of *those* is so imperfect, as sometimes to leave a Chasm for several Years together. But notwithstanding this, I doubt not, but upon the whole they will be found sufficient, to

satisfy

satisfie your Lordship of the general Correspondency
between the *Hypothefis* and the *Phænomena*, in the
feveral Stars; however different their Situations are,
with refpect to the Cardinal Points of the Equator.

As I made more Obfervations of γ *Draconis*
than of any other Star; and it being likewife very
near the Zenith of *Wanfted*; I will begin with the
Recital of fome of them. The Point upon the
Limb, with which this Star was compared, was
38°. 25′ from the North Pole of the Equator, ac-
cording to the Numbers of the Arc of my *Sector*.
The firft Column, in the following Table, fhews
the Year and the Day of the Month, when the Obfer-
vations were made; the next gives the Number of
Seconds, that the Star was found to be *South* of
38°. 25′: the third contains the Alterations of the
Polar Diftance, which the *mean* Preceffion, at the
rate of one Degree in 71½ Years, would caufe in
this Star, from the 27th Day of *March* 1727, to
the Day on which the Obfervation was taken: the
fourth fhews the Aberrations of Light: the fifth,
the Equations arifing from the 'forementioned Hy-
pothefis: and the fixth gives the *mean* Diftance of
the Star from the Point with which it was compared,
found, by collecting the feveral Numbers, according
to their Signs, in the 3d, 4th, and 5th Columns,
and applying them to the *Obferved Diftances* con-
tain'd in the Second.

If the Obfervations had been perfectly exact, and
the feveral Equations of their *due* Quantity; then all
the Numbers in the laft Column would have been
equal; but fince they differ a little from one another;
if the *mean* of All be taken, and and the Extremes are

D   compared

pared with it, we fhall find no greater Difference, than what may be fuppofed to arife from the Uncertainty of the Obfervations themfelves; it no where amounting to more than $1''\frac{1}{2}$. The Hypothefis therefore feems, in this Star, to agree extremely well with the Obfervations here fet down; but as I had made above 300 of it; I took the Trouble of comparing each of them with the Hypothefis: and altho' it might have been expected, that, in fo large a Number, fome great Errors would have occurred; yet there are very few, *viz.* only eleven, that differ from the mean of thefe fo much as $2''$; and not one that differs fo much as $3''$. This furprifing Agreement, therefore, in fo long a Series of Obfervations, taken in all the various Seafons of the Year, as well as in the different Pofitions of the Moon's Nodes, feems to be a fufficient Proof of the Truth, both of *this* Hypothefis, and alfo of *that* which I formerly advanced, relating to the Aberrations of Light; fince the Polar Diftance in this Star may differ, in certain Circumftances, almoft a Minute, *viz.* $56''\frac{1}{2}$, if the Corrections refulting from both thefe Hypothefes are neglected; whereas, when thofe Equations are rightly applied, the mean Place of the Star comes out the fame, as nearly, as can be reafonably expected.

γ Draconis

γ *Draconis*	South of 0 ′ 38. 25	Preces-sion.	Aberra-tion.	Nuta-tion.	Mean Dift.
	″	″	″	″	″
1727 September 3	70.5	— 0.4	+ 19.2	— 8 9	80.4
1728 March 18	108.7	— 0.8	— 19.0	— 8.6	80.3
September 6	70.2	— 1.2	+ 19.3	— 8.1	80.2
1729 March 6	108.3	— 1.6	— 19 3	— 7.4	80.0
September 8	69 4	— 2.1	+ 19.3	— 6.9	80.2
1730 September 8	68.0	— 2.9	+ 19.3	— 3.4	80.5
1731 September 8	66.0	— 3.8	+ 19.3	— 1.0	80.5
1732 September 6	64.3	— 4 6	+ 19.3	+ 2.0	81.0
1733 Auguft 29	60.8	— 5.4	+ 19.0	+ 4.8	79.2
1734 Auguft 11	62.3	— 6.2	+ 16.9	+ 6.9	79.9
1735 September 10	60.0	— 7.1	+ 19.3	+ 7.9	80.1
1736 September 9	59.3	— 8 0	+ 19.3	+ 9.0	79.6
1737 September 6	60.8	— 8.8	+ 19.3	+ 8 5	79.8
1738 September 13	62.0	— 9.6	+ 19.3	+ 7.0	78.7
1739 September 2	66.6	— 10 5	+ 19 2	+ 4.7	80.0
1740 September 5	70.8	— 11.3	+ 19.3	+ 1.9	80.7
1741 September 2	75 4	— 12.1	+ 19.2	— 1.1	81.4
1742 September 5	76.7	— 12 9	+ 19.3	— 4.0	79.1
1743 September 2	81.6	— 13.7	+ 19.1	— 6.4	80 6
1745 September 3	86.3	— 15.4	+ 19.2	— 8.9	81.2
1746 September 17	86.5	— 16.2	+ 19.2	— 8 7	80.8
1747 September 2	86.1	— 17.0	+ 19.2	— 7.6	80.7

I made about 250 Obfervations of β *Draconis*; which I find correfpond as well with the Hypothe-fis, as thofe of γ; but fince the Pofitions of both thefe Stars, in refpect to the Solftitial Colure, differ but little from each other; it will be needlefs to fet down the Obfervations of β. I fhall therefore pro-ceed to lay before your Lordfhip, fome Obfervations of a fmall Star, that is almoft oppofite to γ *Draco-*

nis

conis in Right Afcenfion, being the 35th *Camelo-pardali Hevel.* in the *Britifh* Catalogue. Mr. *Flam-fteed*, indeed, has not given the Right Afcenfion of this Star; but *that* being neceffary to be known, in order to compute the Change of its Declination arifing from the Preceflion of the Equinox; I com-pared the Time of its Tranfit over the Meridian, with that of fome other Stars near the fame Pa-rallel; whereby I found, that its Right Afcenfion was 85°. 54.'½ at the Beginning of the Year 1737.

This fmall Star was compared with the fame Point of the Limb of my Sector, as γ *Draconis*; and the fecond Column, in the following Table, fhews how many *Seconds* it was found to be South of that Point, at the time of each refpective Obfervation. The other Columns contain, as in the foregoing Table, the Equations that are neceffary to find, what its *mean* Diftance from the fame Point would have been on the 27th Day of *March* 1727, which is exhibited in the laft Column. The whole Number of my Obfervations of this Star did not much ex-ceed forty; the greateft Part of which were made before the Year 1730; in fome of the following Years none were taken; and only a fingle one in any other, except in 1739. However, their Corre-fpondency feems fufficient to evince the Truth of the Hypothefis: for if the Mean of thefe, contain'd in the Table, be taken, not one, among the reft of the Obfervations, will differ from it more than 2".

35th

35th *Camelopard. Hevelii.*	South of 0' 38. 25	Precession.	Aberration.	Nutation.	Mean Dist. South.
	''	''	''	''	''
1727 October 20	73.6	+ 0.9	— 6.7	+ 8.9	76.7
1728 January 12	60.8	1.2	+ 6.1	8.8	76.9
March 1	57.8	1.4	+ 9.4	8.7	77.3
September 26	75.2	2.3	— 8.8	8.1	76.8
1729 February 26	56.4	2.8	+ 9.4	7.6	76.2
1730 March 3	57.8	4.4	9.4	5.4	77.0
1731 February 5	59.1	5.6	8.5	+ 3.0	76.2
1733 January 31	64.1	8.7	8.2	— 2.9	78.1
1738 December 30	61.3	17.2	4.3	6.5	76.8
1739 February 4	56.9	17.3	8.5	6.3	76.4
1740 January 20	56.0	18.6	7.0	— 4.0	77.6
1747 February 27	22.3	28.5	9.4	+ 8.1	78.6

The Obfervations of the foregoing Stars are the moft proper, to prove the Change of the Inclination of the Earth's Axis to the Plane of the Ecliptic; thofe, which follow, will fhew in what manner the Stars, that lie near the Equinoctial Colure, are affected, as well as others, that are differently fituated, with refpect to the Cardinal Points of the Equator. Some of thefe Stars are indeed more remote from the Zenith, than I would have chofen, if there had been others, of equal Luftre, in more proper Pofitions; becaufe Experience has long fince taught me, that the Obfervations of fuch Stars, as lie near the Zenith, do generally agree beft with one another, and are therefore the fitteft to prove the Truth of any Hypothefis. I fhall begin with thofe near the Vernal Equinox. α *Caffiopeæ* was compared with the Point marked 34°. 55'; and at firft

was

was found to be more *Southerly*, but afterwards became more *Northerly* than that Point, as in the following Table: the laſt Column of which ſhews its mean Diſtance *South* of that Point on the 27th of *March* 1727. The Obſervation of the 23d Day of *December*, in the Year 1738, differs 3" from the *mean* of the others; as does alſo another, that was taken five Days after this; neither of which being marked as uncertain, I judged it proper to inſert one of them; altho' they give the mean Place of the Star near 2 Seconds more *Northerly* than any other, in a Series of above 100; *all* of which correſpond, with the *mean* of theſe here recited, within leſs than 2"; excepting *two*, that give the Stars mean Diſtance almoſt 3" more *Southerly*; but theſe laſt mentioned are marked as dubious; and indeed they appear to have been bad, by comparing them with ſeveral others, that were made near the ſame time, from which they differ almoſt 2".

α *Caſſiopeæ.*	South of 0 ′ 34. 55 "	Preceſſion. "	Aberration. "	Nutation. "	Mean Diſt. South "
1727 September 9	55.0	+ 9.0	+ 2.2	+ 2.4	68.6
1728 September 17	30.8	29.4	+ 4.6	5.2	70.0
1729 June 8	35.7	43.8	— 16.3	6.8	70.0
December 3	N. 9.4	53.5	+ 16.5	7.7	68.3
1730 June 11	S. 13.8	64.0	— 16.2	8.4	70.0
December 9	N. 30.8	73.8	+ 16.3	8.8	68.1
1732 January 8	N. 49.2	95.4	12.9	8.9	68.0
1733 January 21	64.8	116.0	+ 10.0	7.9	69.1
1734 June 13	62.8	143.8	— 16.1	5.0	69.9
December 11	105.4	153.7	+ 16.2	+ 3.7	68.2
1738 December 23	176.3	234.0	+ 15.2	— 7.2	65.7
1740 June 2	169.1	262.8	— 16.5	— 8.9	68.3
1747 February 27	332.3	397.0	+ 0.2	+ 4.7	69.6

Altho'

Altho' I have taken no Obfervation of τ *Perfei*
fince the 22d Day of *January* 1740; yet, as this
Star is very near the Zenith, and a fufficient Num•
ber were made about the Times when the Equation,
refulting from the Hypothefis, was at its *Maximum* ;
I judged it proper to infert fome of them in the
next Table ; the laft Column of which fhews, how
much the Star's *mean* Diftance was *South* of 38°.
20'. on the 27th Day of *March* 1727. Among
near 60 Obfervations I meet with two only, that
differ from the mean of thefe fo much as 2''; and
thofe differ almoft as much from the mean of others,
that were taken near the fame time: fo that the
Hypothefis feems to correfpond, in general, with the
Obfervations of this Star as well, as with either of
the foregoing.

τ *Perfei.*	South of 38. 20	Precef-fion.	Aberra-ration.	Nuta-tion.	Mean Dift. South.
	''	''	''	''	''
1727 September 16	60.1	+ 7.4	— 3.2	+ 6.7	71.0
December 29	39.7	11.9	+ 12.9	7.2	71.7
1728 December 21	22.5	27.2	12.8	8.7	71.2
1729 December 2 S. 9.2	42.0	11.5	9.0	71.7
1731 January 3 N. 8.2	59.0	12.8	8.3	71.9
1732 January 8	22.0	74.8	12.7	6.7	72.2
1733 January 21	34.6	91.0	11.7	+ 4.3	72.4
1738 December 23	117.0	183.4	12.8	— 9.0	70.2
1740 January 22	132.5	200.2	11.7	8.6	70.8

After the laft recited Obfervations, it may per-
haps feem needlefs to add thofe of α *Perfei*, which
is farther from the Zenith; but however, as this
Star lies very nearly at an equal Diftance from the
Equinoctial

Equinoctial and Solstitial Colures, and the Series of
Observations of it is somewhat more complete, than
that of τ *Persei*; I shall insert one at least, for each
Year wherein it has been observed; whereby it may
appear, that the Hypothesis solves the *Phænomena*
of Stars in this Situation, as exactly as in others:
for if a *mean* be taken of the Numbers in the last
Column of the following Table, which expresses the
mean Distance of the Star *South* of 41°. 5′. on
March 27th 1727, it will agree within two Seconds,
with every one of 80 Observations, that have been
made of this Star.

α *Persei*	South of 41° 5′ ″	Precession. ″	Aberraration. ″	Nutation ″	Mean Dist. South. ″
1727 December 29	79.4	+ 10.5	+ 11.4	+ 7.9	109.2
1728 April 7	87.5	14.3	− 0.8	8.2	109.2
July 5	94.6	17.7	− 11.4	8.5	109.4
December 13	65.7	23.8	+ 10.6	8.8	108.9
1729 December 3	53.4	37.2	9.7	8.9	109.2
1731 January 3	38.6	52.3	11.4	7.8	110.1
1732 January 8	26.8	66.2	+ 11.4	+ 5.9	110.3
1734 July 11	S. 21.3	101.0	− 11.4	− 1.1	109.8
1738 December 24	N. 56.3	162.6	+ 11.2	9.0	108.5
1740 January 21	71.8	177.4	10.9	− 8.2	108.3
1747 February 27	182.5	275.4	6.6	+ 8.5	108.0

Having already given Examples of Stars, lying near
both the Solstices and the *Vernal* Equinox; I shall
now add the Observations of *one*, that is not far
from the *Autumnal* Equinox, *viz.* η *Ursæ Majoris*,
the brightest Star in that Part of the Heavens, which
approaches the Zenith of *Wansted* within a Degree;
and

and which, by reason of its Luftre and Pofition, gave me the Opportunity of making my Series of Obfervations of *It*, more complete than of many others. This Star was compared with the Point marked 39°. 15′. and was *South* of it as in the following Table; wherein your Lordfhip will fee, that the Obfervations of the Years 1740 and 1741 give the Polar Diftances 3″ greater, than the *mean* of the other Years. Had there been only a fingle Obfervation taken in either of thofe Years, Part of this apparent Difference might have been fuppofed to arife from their Uncertainty; but as there were 8 Obfervations taken within a Week, either before or after the 3d Day of *June* 1740, which agree well with each other; and three were made within 20 Days in *September* 1741, which likewife correfponded with each other; I am inclined to think, that the 'foremention'd Differences muft be owing to fomething elfe, befides the Error of the Obfervations. This *Phænomenon* therefore may deferve the Confideration of thofe Gentlemen, who have employed their Time in making Computations relating to the Quantity of the Effects, which the Power of Gravity may, on various Occafions, produce. For I fufpect, that the Pofition of the Moon's Apogee, as well as of her Nodes, has fome Relation to the apparent Motions of the Stars that I am now fpeaking of.

My Series of Obfervations of feveral Stars abound, of late Years, with fo many and long Interruptions; that I cannot pretend to *determine* this Point; but probably the Differences before taken notice of in the Obfervations of α *Caffiopeæ*, and fome others

E   that

that I have found likewise among the Observations of *other* Stars, that are not here recited, may be owing to such a Cause; which, altho' it should not have any large Share of Influence, may yet, in certain Circumstances, discover a Defect in a Hypothesis, that pays no Regard at all to *It*. But whether these Differences do arise from the Cause already hinted at; or, whether they proceed from any Defect of the Hypothesis itself in any other respect; it will not be very *material* in point of Practice; since *that* Hypothesis, as it was before laid down, appears to be sufficient to solve all the *Phænomena*, to as great a Degree of Exactness, as we can in general *hope* or *expect* to make Observations. For if I take the *mean* of all the Numbers in the last Column of the following Table for η *Urſæ Majoris*, and compare it with any one of 164 Observations that were taken of it, the Difference will not exceed three Seconds.

η *Urſæ Majoris*	South of 39. 15	Preceſ-ſion.	Aberra-tion.	Nutation	Mean Diſt. South.
	"	"	"	"	"
1727 October 17	153.3	— 10.2	+ 1.0	— 5.2	138 9
1728 January 24	176.4	15 2	— 17.6	5.8	137.8
July 17	150.8	23.9	+ 17.8	6.9	137.8
October 11	170.6	28.2	+ 2.6	7.3	137.7
1729 January 16	196.6	33.1	— 17.8	7.8	137.9
July 21	170.4	42.4	+ 17.8	8.4	137.4
1730 July 19	189.6	60.6	+ 17.8	9.0	137.8
December 28	232.4	68.7	— 16.7	8.9	138.1
1731 September 18	218.1	81.9	+ 9.4	8.4	137.2
1732 January 10	250.7	87.7	— 17.7	8 0	137.3
April 12	238.7	92.3	— 0.8	7.7	137.9
1734 July 11	255.7	133.3	+ 17.6	— 2.3	137 7

η *Urſæ*

η *Urſæ Majoris*	South of · ʼ 39. 15	Preceſ- ſion.	Aberra- tion.	Nutation	Mean Diſt. South.
	″	″	″	″	″
1735 September 10	280.8	154.6	+ 11.4	+ 1.2	138.8
1736 September 8	294.7	172.8	11.6	4.1	137 6
1737 July 3	303.0	187.8	17.2	6.1	138.5
1738 June 29	319.0	205.8	16.8	7 9	137.9
1739 April 25	348.0	220 8	2.5	8.8	138 5
1740 June 3	360.3	241 1	12.8	8.9	140 9
1741 September 23	390.9	265.0	7.9	+ 7.4	141.2
1745 September 5	466.7	337.1	12.4	− 3.3	138.7
1746 September 20	492.0	356.2	8.8	5.9	138.7
1747 September 2	507.2	373.5	13.2	7.8	139.1

You may perceive, my Lord, by inſpecting the
Tables which contain the Obſervations of α *Caſſio-
pēæ* and η *Urſæ Majoris*; that the greateſt Differences
that occur therein may be diminiſhed, by ſuppoſing
the *true* Pole of the Equator to move round the
Point *P*, in an *Ellipſis*, inſtead of a Circle. For if
the tranſverſe Axis, lying in the Direction *AC*, be
18″, and the Conjugate, as *DB*, be about 16″; the
Equations, reſulting from ſuch an Hypotheſis, will
make the Numbers in the laſt Columns agree with
each other, nearer than as they now ſtand. But
ſince this would not entirely remove the Inequa-
lities, in all the Poſitions of the Moon's Nodes; I
ſhall refer the more accurate Determination of the
Locus of the *true* Pole to Theory; and at preſent
only give the Equations for the Preceſſion of the
Equinoctial Points, and the Obliquity of the Eclip-
tic, as alſo the real Quantity of the annual Preceſ-
ſion, to every 5th Degree of the Place of the Moon's
Aſcending Node, in the following Tables; juſt as

E 2   they

they refult from the Hypothefis, as at firft laid down; it appearing, from what has already been remark'd, that thefe will be fufficiently exact for Practice in all Cafes.

☽ s ☊ from ♈	The Equation of the Equinoct. Points			Subit.
	Sig O / Sig V	I / VII	II / VIII	Add
°	"	"	"	°
0	0.0	1 3	19 6	30
5	2 0	13 0	20.5	25
10	3.9	14 5	21.2	20
15	5.8	16.0	21 8	15
20	7.7	17.3	22.2	10
25	9.6	18.5	22.5	5
30	11 3	19.6	22.6	0
Subit.	Sig. V	IV	III	☽s☊
Add	Sig. XI	X	IX	from ♈

☽s☊ from ♈	The Equation of the Obliquity of the Ecliptick.			Add
	Sig O / Sig VI	I / VII	II / VIII	Subit.
°	"	"	"	°
0	9 0	7.8	4.5	20
5	9 0	7.4	3.8	25
10	8.9	6.9	3.1	20
15	8 7	6 4	2.3	15
20	8.5	5.8	1.6	10
25	8.2	5.2	0.8	5
30	7.8	4 5	0 0	0
Add	Sig. V	IV	III	☽s☊
Subit.	Sig. XI	X	IX	from ♈

☽.☊ from ♈	The Annual Precession of the Equinoctial Points.						
	Sig. O	I	II	III	IV	V	°
°	"	"	"	"	"	"	
0	58.0	57.0	54.2	50.3	46.5	43.7	30
5	57.9	56.6	53.6	49.7	46.0	43.4	25
10	57.9	56.2	53.0	49.0	45.5	43.2	20
15	57.7	55.7	52.3	48.4	45.0	43.0	15
20	57.5	55.2	51.7	47.7	44.5	42.8	10
25	57.3	54.7	51.0	47.1	44.1	42.8	5
30	57.0	54.2	50.3	46.5	43.7	42.7	0
	Sig. XI	X	IX	VIII	VII	VI	☽s☊ from ♈

Sir

Sir *Isaac Newton*, in determining the Quantity of the annual Preceſſion from the Theory of Gravity, upon Suppoſition that the Equatorial is to the Polar Diameter of the Earth as 230 is to 229, finds the Sun's Action ſufficient to produce a Preceſſion of $9''\frac{1}{8}$ only; and, collecting from the Tides the Proportion between the Sun's Force and the Moon's to be as 1 to $4\frac{1}{2}$, he ſettles the mean Preceſſion, reſulting from their joint Actions, at 50''. But ſince the Difference between the Polar and Equatorial Diameter is found, by the late Obſervations of the Gentlemen of the *Academy of Sciences*, to be greater than what Sir *Isaac* had computed it to be; the Preceſſion, ariſing from the Sun's Action, muſt likewiſe be greater than what he has ſtated it at, nearly in the ſame Proportion. From whence it will follow, that the Moon's Force muſt bear a leſs Proportion to the Sun's than $4\frac{1}{2}$ to 1; and perhaps the *Phænomena*, which I have now been giving an Account of, will ſupply the beſt *Data* for ſettling this Matter.

As I apprehend, that the Obſervations already ſet down will be judged ſufficient, to prove in general the Truth of the Hypotheſis before advanced; I ſhall not trouble your Lordſhip with the Recital of more, that I made of Stars lying at greater Diſtances from the Zenith; thoſe not being ſo proper, for the Reaſon before-mention'd, to eſtabliſh the Point that I had chiefly in View. But as it may perhaps be of ſome Uſe to future Aſtronomers, to know what were the *mean* Differences of Declination, at a given Time, between ſome Stars, that lie nearly oppoſite to one another in Right Aſcenſion, and not far from either of the *Colures*; I ſhall ſet down the Reſult of the Compariſon of a few, that differ ſo little in Declination,

that

that I could determine the Quantity of that Difference with great Certainty.

By the *mean* of 64 Obfervations, that were made of α *Caffiopeæ* before the End of the Year 1728, I collect, after allowing for the Preceffion, Aberration and Nutation as in the foregoing Tables; that the *mean* Diftance of this Star was 68″.7 South of 34°. 55′, on the 27th Day of *March* 1727. By a like Comparifon of 40 Obfervations, taken of γ *Urfæ Majoris* during the fame Interval of Time, I find this Star was, at the fame time, 39″.6 South of 34°. 45′. I carefully meafured, with the Screw of the Micrometer, the Diftance between the Points, with which thefe Stars were compared; and found them to be 9′. 59″ from each other, or one Second lefs than they ought to have been. Hence it follows, that the *mean* Difference of Declination between thefe two Stars, was 10′. 28″.1, on the 27th Day of *March* 1727.

By the *mean* of 65 Obfervations, that were taken of β *Caffiopeæ*, before the End of the Year 1728, this Star was 25″.8 North of 32°. 20′, on the 27th Day of *March* 1727: and by the *mean* of 52 Obfervations, ε *Urfæ Majoris* was 87″.6 South of 32°. 30′ at the fame time. The Diftance between thefe Points was found to be 9′. 59″.3; from whence it follows, that the *mean* Difference of Declination between thefe two Stars was 11′. 52″.7 on *March* 27th 1727.

By the *mean* of 100 Obfervations, taken before the End of the Year 1728, the *mean* Diftance of γ *Draconis* was 79″.8 South of 38°. 25′ on *March* 27th 1727; and by the *mean* of 35 Obfervations, the

the 35th *Camelopard. Hevel.* was South of the same Spot 76″.4. So that the mean Polar Distance of γ *Draconis* was only 3″.4 greater, than that of the 35th *Camelopard. Hevel.* but as the Equation for the Nutation, in both these Stars, was then near the *Maximum*, and to be applied with contrary Signs; the *Apparent* Polar Distance of γ *Draconis* was 21″.4 greater, on the 27th Day of *March* 1727.

The Differences of the Polar Distances of the Stars, as here set down, may be presumed, both on account of the Radius of the Instrument and the Number of Observations, to be very exactly determined, to the Time when the Moon's Ascending Node was at the Beginning of *Aries*; and if a like Comparison be hereafter made, of Observations taken of the same Stars, near the same Position of the Moon's Nodes; future Astronomers may be enabled, to settle the Quantity of the mean Precession of the Equinox, so far as it affects the Declination of these Stars, with great Certainty: and they may likewise discover, by means of the Stars near the Solstitial Colure, from what Cause the apparent Change in the Obliquity of the Ecliptic really proceeds, if the mean Obliquity be found to diminish gradually.

The 'forementioned Points indeed can be settled only on the Supposition, that the angular Distances of these Stars do continue always the same, or that they have no real Motion in themselves; but are at Rest in Absolute Space. A Supposition, which though usually made by Astronomers, nevertheless seems to be founded on too uncertain Principles, to be admitted in all Cases. For if a Judgment may be formed, with Regard to this Matter, from the Result

fult of the Comparifon of our beft modern Obfer-
vations, with fuch as were formerly made with any
tolerable Degree of Exactnefs; there appears to have
been a real Change in the Pofition of fome of the fixed
Stars, with refpect to each other; and fuch, as
feems independent of any Motion in our own Syf-
tem, and can only be referred to fome Motion in
the Stars themfelves. *Arcturus* affords a ftrong Proof
of this: for if its prefent Declination be compared
with its Place, as determined either by *Tycho* or
Flamfteed; the Difference will be found to be much
greater, than what can be fufpected to arife from
the Uncertainty of their Obfervations.

It is reafonable to expect, that other Inftances of
the like kind muft alfo occur among the great Num-
ber of the vifible Stars: becaufe their relative Po-
fitions may be alter'd by various means. For if our
own Solar Syftem be conceived to change its Place,
with refpect to Abfolute Space; this might, in Pro-
cefs of Time, occafion an apparent Change in the
angular Diftances of the fixed Stars; and in fuch a
Cafe, the Places of the neareft Stars being more af-
fected, than of thofe that are very remote; their re-
lative Pofitions might feem to alter; tho' the Stars
themfelves were really immoveable. And on the
other Hand, if our own Syftem be at Reft, and any of
the Stars really in Motion, this might likewife vary
their apparent Pofitions; and the more fo, the nearer
they are to us, or the fwifter their Motions are, or
the more proper the Direction of the Motion is, to
be rendered perceptible by us. Since then the Re-
lative Places of the Stars may be changed from fuch
a Variety of Caufes, confidering that amazing Di-
ftance

tance at which it is certain some of them are placed, it may require the Observations of many Ages, to determine the Laws of the apparent Changes, even of a single Star : much more difficult therefore must it be, to settle the Laws relating to all the most remarkable Stars.

When the Causes, which affect the Places of all the Stars in general are known ; such as the Precession, Aberration, and Nutation ; it may be of singular Use, to examine nicely the relative Situations of particular Stars : and especially of those of the greatest Lustre, which, it may be presumed lie nearest to us, and may therefore be subject to more sensible Changes ; either from their own Motion, or from that of our System. And if at the same time that the brighter Stars are compared with each other, we likewise determine the relative Positions of some of the *smallest* that appear near them, whose Places can be ascertained with sufficient Exactness ; we may perhaps be able to judge to what Cause the Change, if any be observable, is owing. The Uncertainty that we are at present under, with respect to the Degree of Accuracy wherewith former Astronomers could observe, makes us unable to determine several Things, relating to the Subject that I am now speaking of : but the Improvements, which have of late Years been made in the Methods of taking the Places of the heavenly Bodies, are so great, that a few Years may hereafter be sufficient, to settle some Points ; which cannot now be settled, by comparing even the earliest Observations with those of the present Age.

P.

It were to be wish'd therefore, that such Persons as are provided with proper Instruments, would attempt to determine, with great Care, the present relative Positions of several of the Principal Stars, in various Parts of the Heavens; especially of those, that are least affected by Refraction: *that* Cause having many times so uncertain an Influence on the Places of Objects, that are very remote from the Zenith; that wherever *It* is concerned, the Conclusions, deduced from Observations that are *much* affected by it, will always remain doubtful, and too precarious, in many Cases, to be relied upon.

The Advantages, arising from different Persons attempting to settle the same Points of Astronomy near the same time, are so much the greater; as a Concurrence in the Result, would remove all Suspicion of Incorrectness in the Instruments made use of. For which Reason, I esteem the curious *Apparatus* at *Shirburn Castle*, and the Observations there taken, as a most valuable *Criterion*, whereby I may judge of the Accuracy of those, that are made at the *Royal Observatory :* and as a Lover of Science I cannot but wish, that our Nation abounded with more frequent Examples, of Persons of like Rank and Ability with your Lordship, equally desirous of promoting *This*, as well as every other Branch of Natural Knowledge, that tends to the Honour and Benefit of our Country.

But were the Patrons of Arts and Sciences ever so numerous, the Subject of my present Letter is of such a Nature, as must direct me, to beg Leave to address it to the *Earl of Macclesfield*; not only as a most competent Judge of it; but as the *sole* Person,

fon, in this Nation, that hath Inftruments proper to examine into the Truth of the Facts here related. And it is a particular Satisfaction to me, that after fo long an Attendance upon thefe *Phænomena*, I am allowed the Honour of tranfmitting the Account of them to the Public, thro' your Lordfhip's Hands: as it gives me at the fame time an Opportunity of profeffing the grateful Senfe I fhall ever retain, both of the fignal Favours which I formerly received from the noble Earl your Father, and of the many recent Obligations conferr'd by yourfelf upon,

My LORD,

> *Your Lordfhip's*
>
> *moft obedient*
> *humble Servant,*

Greenwich, Dec. 31.
1747.

Ja. Bradley.